Dark Matter

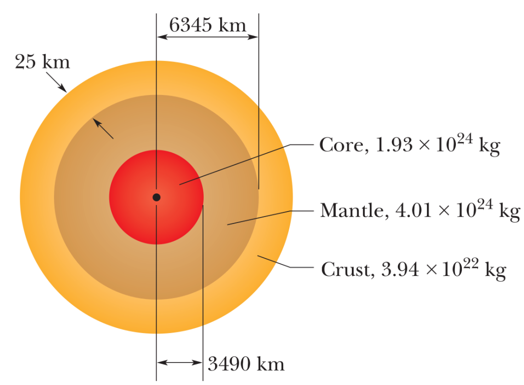
1. The stars on the rim of our Milky Way Galaxy take about 800 million years to orbit in a circle about the galactic core which is a distance $r_G = 9 \times 10^{20}\ m$ away. At this distance from the Galactic center the acceleration due to the gravity created by the other stars in the Galaxy is $g_G = 5.3 \times 10^{-34}\ m/s^2$. Should these stars on the Galactic rim stay in orbit or fly off?

2. When a large star explodes and becomes a supernova the remaining core can become a neutron star. If a neutron star has a radius $r = 10^4\ m$ and rotates every 1.2 s, then what is the centripetal acceleration of a particle on the star's equator?

3. An earth satellite moves in a circular orbit $3.59 \times 10^7\ m$ above the Earth's surface with a period of 1 day or $8.64 \times 10^4\ s$. This is a special orbit called a geosynchronous one. A satellite in this orbit is always at the same point in the sky so it's easy for a ground station to find it. What is the centripetal acceleration of the satellite? How does this compare with the acceleration of gravity on Earth?

4. In a certain binary star system, a small red star with a mass $m \approx 0.22$ solar masses orbits a bright white-hot star with a mass $M = 4.2$ solar masses. The red star is observed to eclipse the other every 482 days. What is the approximate distance D between the centers of these stars if we use the $M >> m$ approximation? What other assumptions (if any) do you have to make to solve the problem?

5. The figure shows, not to scale, a cross section of the Earth. It is divided into three zones: an outer crust, a mantle, and an inner core. The dimensions of these zones and the masses contained within them are shown on the figure. Earth has a total mass of $M_E = 5.98 \times 10^{24}\ kg$ and a radius of $R_E = 6370\ km$. Ignore rotation and assume that Earth is spherical.



   (a) What is a_g, the acceleration of gravity, at the surface.

   (b) Suppose a bore hole is driven to the crust – mantle interface at a depth of $d = 25.0\ km$; what would be the value of a_g at the bottom of the hole?

   (c) Suppose that Earth were a uniform sphere with the same total mass and size. What would be the value of a_g at a depth of 25.0 km? (Precise measurements of a_g are sensitive probes of the interior structure of Earth, although results can be clouded by local variations in mass distribution.)

6. Starting from Newton's Law of Universal Gravitation calculate the potential energy V of a point mass m_1 in the gravitational field of another point mass m_2. Clearly define all the quantities and operations in your calculation.